QUALITY PEDESTRIAN WALKWAYS. A SOLUTION FOR AN EFFECTIVE INTEGRATED TRANSPORT SYSTEM

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ABSTRACT:
This study has analysed the urban mobility of Palermo. The city is characterised by a presence of tourist flows and by an high rate of not systematic mobility.
Particular attention has been put in analysing the transport network. In order to make the public transport system more attractive for the users, the increasing of the pedestrian walkway quality**,** in terms of comfort and environmental quality , could be an effective approach to the problem.
Specific surveys have been conducted in order to measure the pedestrian walkway quality in different areas of the city using a quantitative method.
The research has then verified, by a logic model calibrated using the revealed preference technique, the effect that the level of service of the pedestrian walkways has on the demand modal split.

RESUME : Cette étude analyse la mobilité urbaine à Palerme. La ville se caractérise par l'existence de flux de touristes et par un haut niveau de mobilité non systématique.

On a porté une attention particulière à l'analyse du réseau de transport. Si l'on veut rendre le système de transport public plus attrayant pour les usagers, une approche efficace du problème pourrait être d'augmenter la qualité des chemins piétonniers d'accès au transport, en termes de confort et de qualité environnementale.

Des enquêtes spécifiques ont été menées afin de mesurer la qualité des chemins d'accès pour piétons dans différentes zones de la ville, en utilisant une méthode quantitative.

On a ensuite mesuré, en fonction d'un modèle logique paramétré en fonction de la « technique » des préférences révélées, l'effet du niveau de service des chemins pour piétons sur la répartition modale

1 INTRODUCTION

The re-organisation of a city occurs in terms of improvement of the urban landscape, of the architectural quality, of public spaces, but, above all, through the improvement of the efficiency of infrastructures, networks and facilities which are integrated in the urban fabric.

For this reason, transport and communication systems, parking areas, technological networks, environmental renewal, public spaces and leisure areas, should be planned by projects able to promote efficiently urban transformation and development.

The application of strategic planning measures means, not only thinking about the solution of single problems, valued within a global vision of the city, but also to evaluate their induced effects on the urban context and on the citizen practices and behaviours. Urban planning is therefore fundamental to set up accurate procedures of urban systems evaluation, in order to find a right solution for every urban context.

This research has been oriented towards an integrated approach to systems, methods and instruments that can be used to improve the integration between pedestrian and public transport, two means of transport clearly related each other. Therefore the relationship among public transport systems, planning management and pedestrian mobility planning requires another type of analysis.

The main goal has been improving multimodal trips (walking – public transport), especially in urban areas, where a lot of trips still happen by private means. Considering that pedestrians are the main users of public transport, it is important to analyse the interactions between public transport system and pedestrian means of transport and to investigate pathways and other spaces for transport system users, in terms of quality, safety, security and attractiveness of walkways.

Efforts to improve the attractiveness of public transport system, in the past, was barely addressed on mechanical characteristics and performances of vehicles; nowadays the improvement is directed on the quality of pedestrian paths, on access to the public means of transport and on the urban environment.

The establishment or improvement of existing pedestrian zones in city centres often depends on political choices about city management more than on accurate technical decisions. Projects must be part of a global strategy, using actions directed to improve the quality of urban spaces, the accessibility to public means, the attractiveness of paths, setting common strategy for pedestrian pathways and public transport nodes.

It is necessary to establish, in the city, quality pedestrian paths, not only in terms of quantitative values (flow, speed and density), but also in terms of additional factors as comfort, environmental quality, safety and security. Moreover it is clear that structural projects, supported by strategic plans and accurate technical decisions, seem to be the right solution towards a re-conversion of urban mobility in order to achieve a definitive modal split in favour of public transport means. The integrated management of the different means of transport, respecting to the pedestrians needs, and considering pedestrian facilities, constitutes a strong tool for planning a sustainable urban mobility. Thanks to the improvement of pedestrian mobility, especially inside the city core, it is possible to aim positive effects in terms of environmental quality (reduction of pollution, noise, car accidents) and of urban quality increasing.

2 PALERMO: THE EXAMINED URBAN CONTEXT

This paper shows the application of tested methodologies on the urban context of Palermo.

Palermo is the most important city in Sicily, with a territory of 158 squared km and a population of about 700.000 inhabitants.

Centre of the main directional and administrative functions of the island, as well as of an university that counts about 60.000 students coming from the whole Sicily, the city is also influenced, all over the year, by strong tourist flows. The city is influenced, all over the year, by a flow of about 950.000 tourists (Regione Sicilia, 2001).

Palermo, one of the main city in Italy, as other Italian cities, shows several problems characterising the contemporary metropolis. The city attracts population (students, workers) coming from other parts of Sicily, but, on the other hand, it cannot cover the needs deriving from such condition. The consequences are quite heavy: distortions of the job market (unemployment rate 29%, medium yearly income 10.800 €; Regione Sicilia, 2001), lack of low cost lodges, caused by strong immigration flows, estate speculation, difficulty in administrative and social management of the city.

The social and economic context also affects the urban mobility system that clearly shows the typical problems of all metropolitan areas.

The mobility system, inside the metropolitan area of Palermo, is characterised by a strong lack of railway transport systems, lack of suitable parking areas, lack of a policy in favour of collective transport means. Moreover other problems derived from serious delays in setting up the mobility planning instruments as Traffic Urban Plans (PUT) by the new Italian Road Code.

PUT is a plan characterised by co-ordinated actions in order to improve the conditions of the urban mobility in a short term (2 years at least).

The vehicular congestion is largely diffused and it has assumed in the last years alarming proportion. This phenomenon is caused above all by the inadequacy of the road network that, in despite of the processes of modernisation, is mainly characterised by a road system that is developed inside the old city core, (centre of the main urban activities). On the other hand the congestion derives from the indiscriminate use of private means, whose users are disposed to tolerate the congestion cost. The excessive use of private means produces therefore congestion, pollution, lowering of the urban quality, typical factors of the modern cities.

In despite of low commercial speeds, lack of parking areas, pollution, noise, the users of private means are not oriented in favour of collective transport system. In fact the analysis of the daily mobility (Palermo City Council, 1999), shows that 53% of trips happens by private cars, (1,3 travellers per car); 10% by public means; 10% by two wheels vehicles; 26% by feet; 1% by private cars + public means.

The results of the survey carried out in 1996, in occasion of the Urban Traffic General Plan, has shown that the mobility urban system of Palermo is interested by a really strong flow of private cars: 750.000 daily trips by private cars, with 73.000 trips concentrated in the rush hour (8.00 a.m. – 9.00 a.m.) of a normal working day. It was noticed that 600.000 trips happened inside the city, while 150.000 trips were exchange trips or city - crossing trips.

The survey, carried out along the main roads strictly connected with the urban bypass of the city, allowed to quantify that 390.000 private cars every day move towards and from the city centre.

Social dynamics and practical use of the city, clearly influenced the mobility system of Palermo, that is also interested by relevant flows of wandering and not systematic mobility. That contributes to create an extremely flexible transport demand, influenced by random components.

The composition of trips, in terms of reasons, was valued through specific surveys carried out in occasion of the Urban Traffic Plan (PUT).

The surveys showed that not systematic trips constitute 69% and 48% of the total trips respectively in case of inside–city trips and exchange or crossing-city trips. These non systematic trips are more relevant in Palermo than in other European cities.

The re-organisation of urban and metropolitan mobility system, in addition to the urban environment safeguard, are therefore the most important themes in the government politics of Palermo. Efficiency, effectiveness of the urban transport systems can be realised by policy in favour of integrated interventions founded on strategies that can stimulate the use of public transport means in the central areas of the city. That actions are supported by the strategic content of the PUT: "improvement of road flow performances, road safety, reduction of pollution and noise, energy saving, agreement with urban plans and respect of the environmental values."

3 THE SURVEYS

The analysis has examined the trips inside the city of Palermo with final destination the University Campus.

This choice was taken to individuate a wide zone, which was strongly interested by trips, as well as clear trip motivation (job–study). Moreover the university campus was analysed in PUT traffic analysis as a unitary survey zone. It means that it has been possible to use the data concerning the private mean trips towards the university campus by PUT traffic analysis.

In occasion of PUT traffic surveys, a zoning of the city has been made taking into account the district areas, as well as the housing density. Starting from the PUT unitary survey zone, it has been therefore individualised some macro-zones, generated by sum of some PUT unitary survey zone. In every macro-zones it was calculated the private car flows during the rush hour of a normal working day directed towards the university campus.

Moreover, in order to know the trips towards the University Campus, made by other transport means, other investigations have been carried out in order to know the flow of pedestrians coming inside the university campus. It was noticed that, during the period 8.00 a.m. – 9.00 a.m. of a normal working day, about 1200 users crossed the University Campus gates.

About 250 interviews have been conducted to the pedestrians who crossed the University Campus gates in order to establish the origin of trips, as well as the mean used.

The set of question was: the start point of the trip (address), information about the transport mean used (walking, bus, underground), information about the pathway of the used means.

The results of the survey were used to assign the origins of the users inside a macro-zone.

In each macro-zone it was established the number of the trips towards the University Campus, separated for different means: private car (850 users in total), underground (72 users in total), bus (280 users in total) that constitute the total modal split of the users for these three different modes.

The following step of the investigation has concerned an analysis of the public transport paths used by the interviewed users, in order to understand and classify, starting from the origin of the users, the pedestrian walkways.

Starting from the consideration that the distance between two next bus stops in Palermo is about 200 meters and that the distance that users are disposed to walk towards the public mean is about 400 meters, it has been individualised the main pathways covered by users to get bus or underground.

The selected roads were different in terms of geometry, level of service and functions (district roads, connection road, etc.).

Among the individualised roads, some of that with different characteristics have been chosen in order to produce interviews to the pedestrians. The investigations have been done in order to establish the pedestrians path quality and the satisfaction degree of the users. Finally, opportune elaboration of the data was conducted in order to establish the level of service of the pedestrian paths.

4 THE QUALITY OF THE PEDESTRIAN WALKWAYS: THE ADOPTED METHODOLOGY

The pedestrian facilities, as the other transport's infrastructures, must be characterised from an high level of quality. That is essential to guarantee the efficiency which the pedestrian infrastructure requires.

Traffic engineers use the level of service (LOS) concept. It was first developed for vehicular capacity studies connected with road design.

The infrastructures to the pedestrian movement are often assimilated to the traditional road infrastructures in terms of level of service. For instance, the HCM (Highway Capacity Manual) provides guidelines for evaluating level of service, based primarily on performance element, such as flow, speed and density (National Research Council, 1994).

For a complete evaluation of a pedestrian system, it is necessary that qualitative elements, such as attractiveness, comfort, convenience, security and safety, can be taken into account by using a revealed preference technique.

An evaluation methodology (Khisty, 1994) has been used for the assessment of qualitative elements

of facilities used by pedestrians (familiar observers with the situation).

The basic input in selecting potential performance measures - point of departure of the job - consists in the selection of environmental parameters of performance derived from literature of traffic engineering and environmental psychology. Nearly 20 Environmental Performances Measures (EPMs) were chosen, extracted by this review and concerning indicators as comfort, convenience, attractiveness, economy of walking, equipment of the paths, public and personal safety.

These parameters have been reduced (on the basis of duplication, relevance and data availability) to four. They are:

Attractiveness. This EPM is much more encompassed than aesthetic design. It is considering, beyond the function of safety, comfort and convenience, latent function such as pleasure, delight, interest and exploration.

Comfort. Factors as weather protection, climate control, design shelter, condition of walking surface, cleanliness of terminals and provision of adequate seating arrangement, could be considered to provide comfort. Other factors such as pollution, noise ventilation can be also included.

Convenience. Walking distances connected with attributes such as pathway directness, grades, sidewalk ramp locations, directional signing, maps and other features making walking easy are qualities of convenience.

Safety and Security: The reduction of pedestrian–vehicle conflicts can be considered the main factor for safety. Walking in a car free areas such as malls, passageways, sidewalks, stairs, elevators, ramps, escalators, is considered part of safety. On the other hand, security is an EPM related to provide particular pedestrian facilities able to provide clear observation by the public and the police through good light, absence of concealed areas and surveillance.

Before applying the methodology, it was necessary to rank the chosen EPMs on a five point scale, from a level of service A = 5 point (the best), to a level of service F = 0 point (the worst) as shown in the table 1.

Table 1: The EPMs on a 5 point scale.

85% satisfied users	= 5 points
65% satisfied users	= 4 points
45% satisfied users	= 3 points
30% satisfied users	= 2 points
15% satisfied users	= 1 point
less than 15% satisfied users	= 0 points

In order to weight the EPMs, the method of the constant sum, paired – comparison method, that represents a systematic approach in order to identify the relative importance of each factor in a large number of factors, using group consensus, has been used.

On the basis of a preliminary survey, this type of scaling and assignment of points, not only coincide with the level of service ranking as used in HCM, but also seemed to be a pragmatic way of measuring the feeling of satisfaction or not satisfaction expressed by the users.

The user must pronounce an absolute qualitative evaluation (answer yes or answer no) to the questions. Then, it is possible to calculate, using a reliable sample, the rate of satisfied users.

A simple matrix could represent every possible comparison among different EPMs (A versus B, A versus C, A versus and so on).

To each interviewed user was asked to distribute a constant values, 10, among every couple of factors. An example is reported in the table 2.

Table 2: The constant – sum, paired comparison method.

Attractiveness	10	Comfort	0
Attractiveness	5	Convenience	5
Attractiveness	4	Security	6
Comfort	7	Convenience	3
Comfort	2	Security	8
Convenience	3	Security	7

The obtained results were summed for each environmental parameter and normalised respect to the total sum of the single factor results.

The weight of every EPM is given by the relationship of the sum of the single EPM and the total sum.

The different weights related to the four environmental parameters are classified in decreasing order. Moreover, in order to appraise the response of all the interviewed users is necessary to add the weights of all the single consumers and to divide them for the number of the interviewed users.

The application of the constant – sum, paired comparison method, to the four EPMs, produced the results used to quantify the pedestrian walkway quality. The results are refereed to a sample of 500 users of Palermo pedestrian mobility system.

5 THE INFLUENCE OF THE PEDESTRIAN WALKWAY QUALITY ON THE MODAL SPLIT.

In order to evaluate the influence of the pedestrian walkway quality on the attractiveness of the integrated public transport system, a logit model (De D. Ortùzar, J. & Willumsen, L. G., 1994) has been calibrated in order to explain the modal split observed and carried out by the surveys among private car, bus and underground.

Different Origin–Destination (OD) relations – inside the urban area of Palermo and having as destination the university campus – have been analysed.

The utility function for the private car has been expressed as follows:

$$V_a = b_1 * t_a + b_2 * c_a \quad (1),$$

where t_a = time spent between Oi and Dj by car, expressed in hours; c_a = perceived cost between Oi and Dj by car, expressed in euros; b_1, b_2 = weights of the utility function.

The utility function for the bus has been expressed as follows:

$$V_b = b_1 * t_b + b_2 * c_b + b_3 * BUS + b_5 * IPQ \quad (2),$$

where t_b = time spent between Oi and Dj by bus expressed in hours; c_a = perceived cost between Oi and Dj by bus expressed in euros; *BUS* = 1 in the bus utility function, 0 otherwise; $IPQ=\log(1+\Sigma_s w_s EPM_s)$ b_3, b_5 = weights of the utility function.

The utility function for the underground has been expressed as follows:

$$V_u = b_1 * t_u + b_2 * c_u + b_4 * UND + b_5 * IPQ \quad (3),$$

where t_u = time spent between Oi and Dj by underground expressed in hours; c_a = perceived cost between Oi and Dj by underground expressed in euros; *UND* = 1 in the underground utility function, 0 otherwise; $IPQ=\log(1+\Sigma_s w_s EPM_s)$ b_4 = weight of the utility function.

The time spent by car between different Oi-Dj was estimated using an urban transport network modelling by nodes, links and cost functions on the links.

The time spent by bus between different Oi-Dj was estimated using a public transport network modelling by hyperpath minimum algorithm (Cascetta E., 1998).

The time spent by underground between the stations was estimated consulting the timetable.

Specific surveys were conducted in order to estimate, for the different origins of the trip, the weights and the values of the EPMs, as it was explained in the previous paragraph.

The expression of the logit model that reproduces the demand modal split can be written as follows:

The results of the calibration process are reported in

$$P_m^{OD} = \frac{e^{V_m^{OD}}}{\sum_k e^{V_k^{OD}}} \quad (4)$$

the table 3.

Table 3: The results of the calibration process of the modal split logit model.

	b_1	b_2	b_3	b_4	b_5
value	-3,37	-4,94	-3,34	-4,89	3,82
t-Student	-3,55	-3,91	-2,15	-2,77	1,92
R^2	0,88				
Adjusted R^2	0,77				
F-Fisher value	5,66				
degrees of freedom	6				

As can be observed, the b_i parameters have statistically significant values and the F-Fisher value is higher than the critic value, for a significant level of 5%, equal to 4,39.

As an example, in the table 4 are reported the modal split estimated by logit model for 4 different relations in the rush hour (8-9 A.M.) with the actual values of the quantitative attributes.

In the table 5 are reported the variations in the modal split improving the pedestrian walkway quality of 20%.

Therefore this test shows the significant role that the pedestrian walkway quality can have to increase the public transport users.

Table 4: Modal split estimated by logit model for four different relations in the rush hour (8-9 A.M.) with the actual values of the quantitative attributes.

	O_1-University	O_2-University	O_3-University	O_4-University
car	39%	23%	7%	22%
bus	24%	31%	42%	23%
underground	37%	46%	51%	55%

Table 5: The variations in the modal split improving the pedestrian walkway quality of 20%.

	O_1	Δ	O_2	Δ	O_3	Δ	O_4	Δ
car	29%	-10%	15%	-8%	4%	-3%	14%	-8%
bus	28%	+4%	34%	+3%	43%	+1%	25%	+2%
und.	43%	+6%	51%	+5%	53%	+2%	61%	+6%

6 CONCLUSIONS

In this paper a methodology has been used to quantify the quality of pedestrian walkways in urban areas.

In particular, different Origin–Destination (OD) relations– inside the urban area – have been analysed in order to calibrate a multinominal logit model to explain the observed modal split.

The calibrated model has shown the significant value of the parameter regarding the pedestrian walkway quality.

Moreover an increasing of the public transport users has been shown on different OD relations when the pedestrian walkway quality has been improved.

Finally it has been observed that the integration between the public transport system and quality pedestrian walkways could be a good practise in order to increase the attractiveness of the public transport system. In congested areas the increasing of the public transport users is one of the most important strategy for a sustainable development of urban mobility.

Then the same practise could be exported in similar urban contexts, as well as in developing country cities. In fact, the interactions between public

transport system and pedestrian walkways and the improvement in terms of quality, safety, security and attractiveness of walkways and other spaces for transports system users, could contribute to make the public transport system of developing cities more efficient and effective.

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